PRESS RELEASE

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A&A special feature
The XXL Survey: First results

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Astronomy & Astrophysics is publishing a special feature on the first results of the XXL Survey. XXL is a large survey of the X-ray sky with the _XMM-Newton_ ESA observatory. Its goal is to detect a few hundreds of clusters at a look-back time when the age of the Universe was about half its present value (z~1).

Astronomy & Astrophysics is publishing a special feature on the first results of the XXL Survey. XXL is a large survey of the X-ray sky with the *XMM-Newton* space observatory. It aims to detect a few hundreds of clusters back to a time when the age of the Universe was about half its present value (z~1). With this information, astronomers will be able to infer the evolutionary properties and spatial distribution of the massive structures of the universe and, subsequently, to test various cosmological properties.

The distribution of matter in the Universe has a history: very small density perturbations, which were present at the time of recombination (just after the cosmic microwave background (CMB) was emitted) grew under the competing actions of gravity and expansion of the space-time. This progressively formed a remarkable network of filaments, sheets, and voids. Over time, matter has flowed along these filaments: overdensities have become denser and low-density regions emptier. Tracking the evolution of the cosmic structure traces back this process. It corroborates the cosmological constraints inferred from the CMB (z~1000) and from the distribution of matter at much later times (z~0-4). Clusters of galaxies, which are the most massive objects in the Universe, probe the largest scales of the matter distribution. Located at the nodes of the cosmic web, they are huge reservoirs of hot gas that fills the space between their galaxies. The temperature of this gas is a few tens of millions degrees, and it consequently emits X-rays.

The XXL X-ray observations were performed between 2011 and 2013 by *XMM-Newton* and cover two extragalactic regions of 25 deg2 each (named XXL-N and XXL-S). The total observing time was 6 million seconds, making XXL the largest XMM program undertaken since the 1999 launch of the observatory. The analysis of the data required sophisticated detection algorithms because the cluster signals are faint.

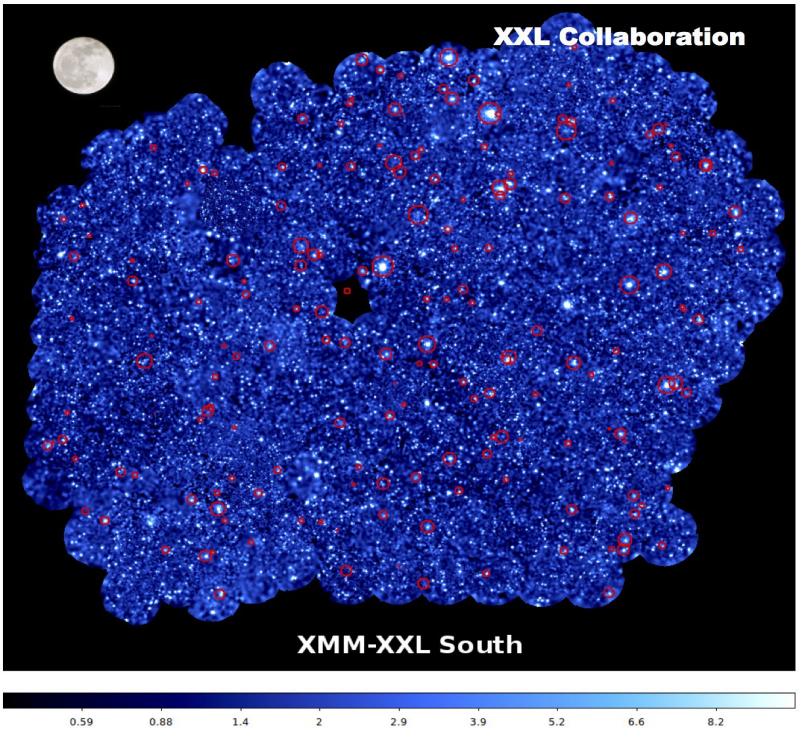

Fig. 1a. XMM image of field XXL-S. The two 25 deg2 fields of XXL are covered by some 540 XMM pointings. The XMM field of view is comparable to the size of the Moon (30' diameter). Over 12000 AGNs are detected in this image. The red circles show the clusters of galaxies. Along with field XXL-N, XXL-S is, by far, the largest view of the deep X-ray sky obtained to date. (XXL Collaboration, S. Snowden, L. Facciolo, F. Pacaud).

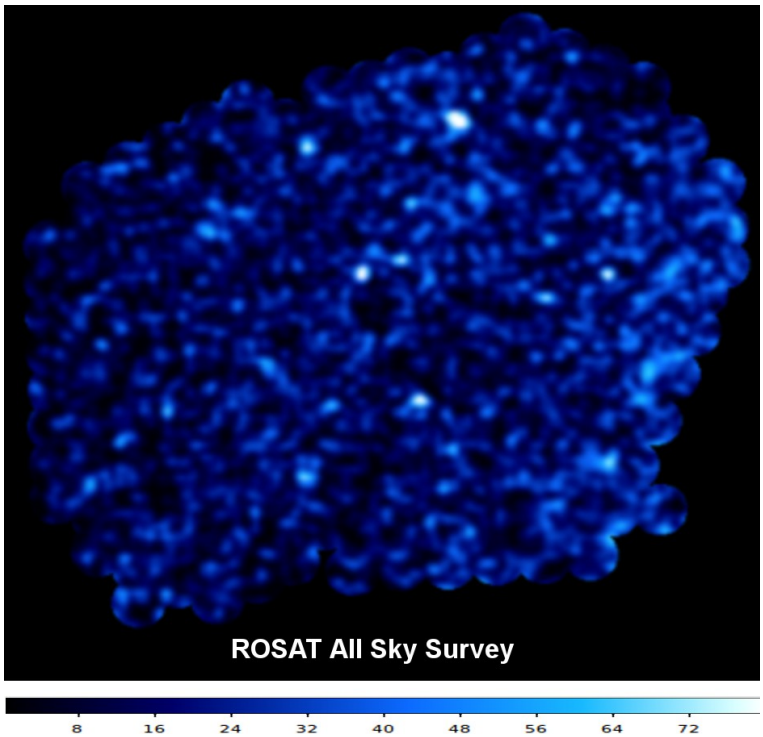

Fig. 1b. The XXL-S area as observed by ROSAT in 1999, for comparison. Only 45 sources were detected in this image.

Any cosmological analysis based on clusters needs the total mass of each cluster (the sum of its galaxies, gas, and dark matter). This is challenging and requires information assembled from all over the entire electromagnetic spectrum. To characterize the properties of the detected clusters and active galactic nuclei (AGNs), the XXL Survey is therefore accompanied by coordinated observations with the largest ground-based and space observatories, covering all wavelengths from X-ray to radio. Of these, the ESO large program (2013-2015) is of particular relevance because it measures the redshifts of the clusters, and therefore locates them in the 3D space. Clusters out to a redshift of ~0.5 were observed at the ESO NTT with the EFOSC2 spectrograph and the more distant ones ($0.5<z<1.2$) with the FORS2 instrument on the VLT. Detailed investigations of the galaxy dynamics and properties of individual clusters have been undertaken at the *William Herschel* Telescope. The redshifts of the many detected AGNs are also being systematically measured with the AAOmega instrument on the Australian Astronomical Telescope. In addition, radio follow-up of the X-ray AGNs is being undertaken with the GMRT, VLA, and ATCA telescopes.

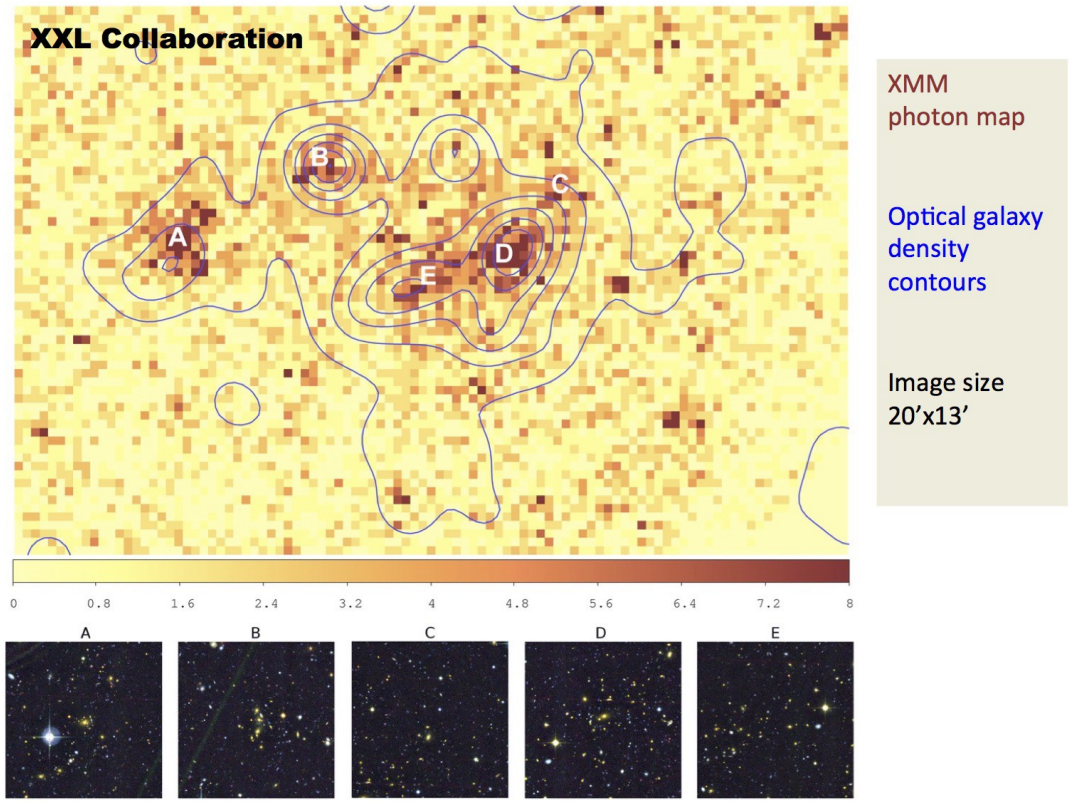

Fig. 2. Supercluster detected in field XXL-N. The supercluster consists of five groups of galaxies at redshift z~0.45 (the redshift was measured with the VLT). The inserts show the five individual groups in optical images extracted from the CFTH Legacy Survey (XXL Collaboration, Papers I and VII).

The XXL survey detects some 450 clusters and 25 000 AGNs. The series of XXL articles published in this special feature releases catalogs of the brightest 100 clusters and 1000 AGNs, and presents a number of scientific results for the low-mass range which, to date, has been barely explored. Among these, Pompei et al. describe one of the five newly discovered superclusters. The inferred X-ray luminosity evolution shows that clusters in the past were scaled replicates of the local ones, as a function of mass (Giles et al.) The number density of clusters is lower than predicted by the *Planck* CMB cosmology, but this trend is similar to that found for the Planck cluster of galaxies sample for a different cluster mass range. (Pacaud et al.). More work on cluster masses, involving information from other wavelengths, will help understand this enigma.

The next cosmological analysis of the full XXL cluster sample (release date in 2017) will involve five times as many clusters, enabling better constraints on cluster physics, hence providing mass estimates at the level required for precision cosmology.

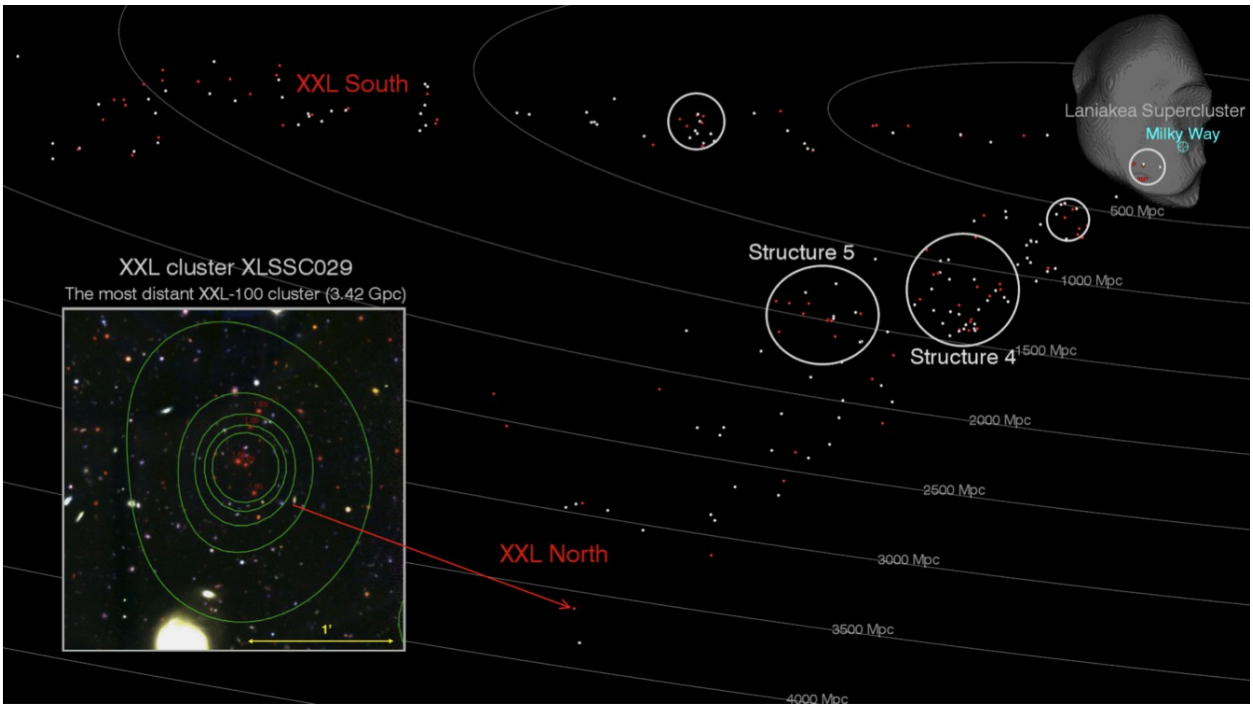

Fig. 3. Animated perspective view of the distribution of the XXL clusters. Some 300 clusters (dots) are shown in the image; the red dots represent the 100 brightest cluster samples. (XXL Collaboration, D. Pomarède). The video is available online.

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Table of contents of the special feature

Online edition of this press release

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